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MINIATURE AIRPLANES.

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Since one of my articles was devoted to giant aircraft, it seems logical now to turn to the other extreme, and to examine the minimum limits, to see something of the smallest airplanes that have been flown successfully.

Many aeronautical engineers will regard the writer as foolish in giving such serious attention to the miniature airplane. There is no doubt, however, that something must be done to reduce the cost of flying if the ownership of airplanes is to gain ground among the general public, and the work done on tiny airplanes with engines of minimum size is at least an encouraging sign that effort in that direction is not being entirely neglected. Such airplanes may not survive in their present form, but they form an important step in the progress toward the popularization of aviation as a sport.

In dealing with small airplanes, the problem of the aviette, or manpower flying machine, is a subject of interest in itself, and it will be reserved for separate treatment. The present discussion will treat, then, only of the smallest airplanes equipped with engines, although there is no question that the winged bicycle with which Poulain made a series of brief flights a few months ago is absolutely the smallest man-carrying, heavier-than-air craft that has ever achieved any measure of success.

There are two points of view from which the very small airplane may be considered, and the difference between them is a dif-

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ference in the definition of "smallness." While one group of experimenters have concerned themselves with minimum dimensions and have sought to build a man-carrying airplane which could be packed into the smallest possible space, another set, somewhat more limited in numbers, have been interested rather in designing for minimum power, a quest which, carried to an extremity, might be expected to lead to the development of an airplane requiring less power than the ordinary man can exert continuously, and so on to the truly practical aviette. Incidentally, it may be remarked that that point is far from being reached as yet.

It might appear at first that the two problems are essentially the same, and that the airplane of smallest dimensions will also be that of minimum power. That is not literally the case, however, although it is true that the airplanes satisfying the two conditions are not very dissimilar. They are not exactly alike because flight with minimum power requires a low speed of flight. Low speed can only be obtained if the load per unit of wing area is kept low, and that in turn involves a reasonably large wing area. On the other hand, to fly with very minute wings requires high speed and so high power for the weight carried.

There have been several airplanes built with wing spans of not more than 16 feet, and one in which, by superposition of several wings, the span has actually been cut to 13 feet. It is rather hard to say what dimensions it may be possible to attain in the future, since, as will be shown a little later, the problem is largely one of control and of accommodations in the body. It may

safely be predicted, however, that the loading of the wings on small airplanes will not rise to more than 12 pounds a square foot of wing surface, and that the total weight of the structure and engine of the airplane to carry a man cannot be cut below 200 pounds. With a 150-pound pilot, the total weight would then be 350 pounds, and the wing surface would have to be 350 divided by 12, or a little less than 30 square feet. With a biplane wing arrangement this would permit of a span of only about nine feet if no difficulty arose in connection with control or otherwise, so that diminution beyond the present minimum may reasonably be expected.

It should be pointed out, however, that these small and heavily-loaded airplanes are exceedingly tricky in flight and can only be handled by a skilled pilot. The flying machine of minimum dimensions is not and does not seem liable ever to be suitable for the use of the average sportsman to whom it might be expected to make appeal at first sight. The day of everyman's airplane of moderate cost is approaching, but the way to its realization does not lie in the direction of extreme compactness.

When attention is given to minimum power rather than to minimum span a first survey of history proves rather discouraging, because it seems to indicate an entire lack of progress in aeronautical engineering in the last decade or more. Some of the most remarkable records ever established in the way of flying with low powers were set up as long ago as 1908 and even earlier. In fact, the first flights ever made, those of the Wright Brothers in 1903,

were carried out with an engine credited with developing only 12 horsepower when started and somewhat less than that after a few minutes' running. It is very exceptional to see even an experimental airplane flying with as little power as that today.

There are several reasons for this apparent retrogression. The most obvious, and the most important, is that more is expected of the airplane now than in 1903 or 1908. At that time a flying machine had fulfilled its mission, and established its constructor as a leader in aeronautics, if it got off the ground and flew for a short distance straightaway under ideal conditions. At the earlier of the dates mentioned even less was required, since the early Wright airplane did not have to get into the air unaided, but was assisted by a launching gear on the ground. In 1922, however, when five-mile cross-country flights have been accomplished by gliders, an airplane is not worth building at all unless it can be counted on to reach an altitude high enough to make ordinary cross-country trips with safety, and it must have a reserve of power sufficient for climbing out of a field and for ordinary maneuvering. If nothing were exacted except what was considered satisfactory 15 years ago it would be easy to build an airplane to fly with three horsepower, quite eclipsing the best records in power reduction made by the pioneers. As a matter of fact several airplanes have made successful straightaway flights with about six horsepower.

The airplane of absolute minimum power, like that of minimum span, cannot be considered a satisfactory sporting machine, despite the low cost at which it can be produced. Flight with a small re-

serve of power is dangerous, particularly in bad weather or with an unstable airplane liable to fall into a spin when turning in too small a circle. Although the type of training which pilots received and the sort of work that they did during the war has led to a cult of excessive power (the sporting airplane has no need of engines of such capacity as have been developed for combat work in the last few years), nevertheless the power must not be cut too far, and experience indicates that it is not wise to try to put on the market for general use or to do serious flying with a single-passenger airplane of less than 30 horsepower. A great deal of flying has been done with motorcycle power plants, but they are not quite powerful enough to give satisfaction.

The technical peculiarities of the small airplane are concerned chiefly with the necessity of very light construction on a small scale. An entirely different practice is necessary, for example, in the building of ribs 30 inches long and those 10 feet in length. One of the greatest benefits that is likely to arise from the glider competitions started in Germany and now spreading to other countries is the gathering of information on cheap and light construction of small parts carrying light loads, for, as already noted, the load per unit of area must be light if the power required for flight is to be kept to a minimum, and the wings must therefore be large. There is, of course, a point beyond which increase in wing area to decrease the loading becomes unprofitable, for the growing size of the wings must in itself lead to an increase in the total weight to be carried, but the wing area for best results is

large enough so that the structure of wings and body is required to be extremely light. The exact best area would depend on the wing form used and on a number of points in the design of the particular airplane considered, but it may be said roughly that in general the least horsepower will be required to fly when the area of the wings is about 200 square feet for a lightly built, single-passenger airplane. To carry a total weight of 400 pounds with that area and with 10 horsepower should be easy, and the increase of the power to two or three times that amount makes ample provisions for that reserve of power the necessity of which has already been suggested.

There are two possible methods of attack in the design of the miniature airplane. One is to copy on a small scale what is already being done in airplanes of larger size, the other to strike out on entirely new lines. The first procedure seems the simpler, but some difficulties arise in carrying it through, owing to the fact that, while all the parts of the airplane itself may be reduced in size in the same proportion, the size of the pilot cannot very well be cut down.

The dimensions of the body are fixed by the necessity of housing the pilot inside, and the body therefore appears disproportionately bulky on the very small types patterned in their general arrangement after much larger designs. While the strangeness of appearance is not a serious drawback in itself, the large cross-section of the body causes it to interfere with the flow of air and so to decrease the effectiveness of the control surfaces,

across which the air should flow smoothly for maximum effect. There has been complaint in a number of instances that miniature airplanes do not answer their controls well. Some serious accidents have resulted, and this screening of the control surfaces by the body has no doubt been a contributing factor. It can be overcome by careful arrangement of the parts, but the very possibility of the existence of any such trouble emphasizes the necessity of careful laboratory tests on the controls, using a model for carrying out such tests before the airplane is built. In this way the danger of discovering the controlling means to be ineffective after the airplane is in the air, so needlessly risking a pilot's life, can be avoided.

If entirely new lines of design are to be tried there are many avenues open, and a number of schemes have been tentatively investigated. One of the most interesting is the plan of carrying the tail on a single outrigger and seating the pilot astride of the outrigger in a little coracle-like projection just large enough to hold him, thus much reducing the obstruction forward of the tail and at the same time securing a very light body construction. Another plan recently brought forward eliminates the danger of screening of the control surfaces by going back to the old "tail-first" construction, placing the rudder and elevators ahead of the wings.